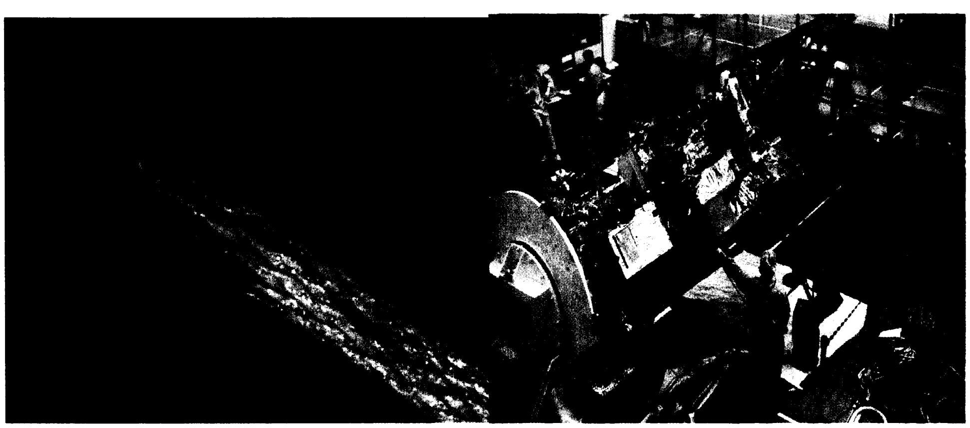
Investigation of the NOAA N' Search and Rescue Antenna Inadvertent Deployment

Type C Mishap

For Public Release

Final Report with Endorsements and Final Approval by Appointing Official



October 24, 2007

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FOREWORD

The Search and Rescue Antenna (SRA) Inadvertent Deployment Mishap Investigation Team (MIT) was commissioned to gather information; analyze the facts; identify the proximate causes, contributing factors, and root causes relating to the mishap; and recommend appropriate actions to prevent a similar mishap from recurring in the future.

CHARTER

Reference NPR 8621.1 "NASA Procedural Requirements for Mishap Reporting, Investigating, and Recordkeeping" for establishing the NOAA-N Prime SAR Antenna Inadvertent Deployment Mishap Investigation Team (MIT) and sets forth its responsibilities and membership.

In accordance with the NPR, the NOAA-N Prime SRA Inadvertent Deployment Mishap Investigation Team is established to gather information; analyze the facts; identify the proximate cause(s), root cause(s) and contributing factors relating to the mishap; and to recommend appropriate actions to prevent a similar mishap from occurring again.

The Chairperson of the Team will report to the Appointing Official on all aspects regarding this investigation.

The Team will:

- Obtain and analyze whatever evidence, facts, and opinions it considers relevant.
- Conduct tests and any other activity it deems appropriate.
- Interview witnesses and receive statements from witnesses.
- Impound property, equipment, and records as considered necessary (consistent with the agreements with the international partners and contractors).
- Determine the proximate cause(s), root cause(s), and contributing factors relating to the mishap.
- Develop recommendations to prevent similar mishaps.
- Provide a final written report that will conform to all requirements in the referenced NPR.

The Chairperson will:

- Conduct Team activities in accordance with the requirements in NPR 8621.1.
- Establish and document, as necessary, rules and procedures for organizing and operating the Team, including any subgroups, and for the format and content of oral or written reports to and by the Team.
- Designate any additional representatives, advisors, consultants, experts, liaison officers, or other individuals who may be required to support the activities of the Team and define the duties and responsibilities of those persons.
- Designate another voting member of the Team to act as chairperson in his or her absence.
- Document meetings and retain records.
- The Team will provide a final report within 75 workdays.

Mishap Date: April 14, 2007

The following individuals are the voting members of the MIT:

Name	Organization	Responsibility on Board
Eric Clemons	NOAA	Member
Mike Hagopian	NASA	Member
Phil Sabelhaus	NASA	Chairperson-Member

The following individuals will serve as the Ex Officio on the MIT, and complete applicable tasks as outlined in NPR 8621.1:

Name	Organization	Responsibility on Board
Jerome Kosko	NASA	Ex Offcio

EXECUTIVE SUMMARY

The NOAA N' Search and Rescue Antenna (SRA) inadvertently deployed during a spacecraft rotation on April 14, 2007. This rotation was part of a normal operation to configure the spacecraft for additional antenna and the solar array boom deployments. This procedure (red flag written) had been modified to look for a lost metal washer and a thermal blanket button. The modification to the procedure was reviewed and approved by the Lockheed Martin Missiles and Space (LMMS) Material Review Board (MRB) per standard procedures. The flag to the procedure introduced a counter clockwise rotation before the normal clockwise rotation. The antenna was temporally stowed and held in place via lacing cord. The lacing cord broke and allowed the SRA to inadvertently deploy during the clockwise rotation. The SRA broke through a hard stop bracket and damaged an instrument optical sensor radiator panel. The satellite damage appears to be minimal and there were no injuries to personnel. The damage to the Advanced Microwave Sounding Unit (AMSU)-A1 instrument has not been fully assessed.

Based on mishap site visits, interviews and data analysis, the Mishap Investigation Team (MIT) identified the underlying causes of the mishap. Event and causal factor tree diagrams were developed, resulting in the identification of the proximate (or direct) cause and root causes of the mishap.

Proximate Cause:

- Proximate Cause (PC)- As tied (with a box knot), the lacing system used to temporarily stow the SRA, could not support the loads it was subjected to during the rotisserie/horizontal operation.
  - Contributing Factor 1 (CF1)- The tie procedure is non-specific and will not result in a consistent tie performance: no specific requirement of which lacing cord to use (3 sizes were available for use), instructions of how to tie the lacing cord are vague and technician access is limited. Therefore the load capability of as-tied lacing cord restraint is not deterministic.
    - CF1A- Failure analysis showed the lacing cord used met its manufacturing specifications but that its strength was reduced by ~50% with the introduction of a box knot.
    - CF1B- Structural analysis showed insufficient load-carrying capability of this lacing cord. Load carrying capability of this tie restraint system had never been analyzed prior to the mishap. Subsequent analysis predicts a tension load of up to 69 lbs, which exceeds the specified lacing cord strength of 50 lbs, and the nominal knotted strength of 28 lbs.
  - Contributing Factor 2 (CF2)- A Functional Failure Modes and Effects Analysis (FFMEA) was not performed for the satellite in this configuration (using a lacing cord tie restraint system for the SRA) and subjected to this operation (horizontal rotisserie).

- Contributing Factor 3 (CF3)- Preferred hard stows were difficult to implement since the "Big Joe" lift was removed from usage in 2002.
- Contributing Factor 4 (CF4)- The SRA stow procedure did not specify any operational constraints or restrictions.

Root cause and Recommendations:

- Root Cause (RC)- Lack of due diligence, inadequate Engineering/Management practices which led to a vague procedure.
  - Recommendation 1 (R1)- Evaluate all spacecraft configurations to ensure adequate margin exists for the stowage of all deployables.
    - R1a- Minimize the use and time allowed for temporary stowage of deployables.
    - R1b- Reexamine all spacecraft configurations for the safety of flight hardware and personnel.
  - Recommendation 2 (R2)- If used, the load carrying capability of this tie approach should be conservatively assessed.
    - 2A (R2A)- Perform FFMEAs and ensure conservative load carrying capability for this or any temporary stow approach includes appropriate factors of safety for a proposed operation.
  - Recommendation 3 (R3)- Review all heritage spacecraft procedures that address deployable stowage to ensure they are specific on the type and size, number, location and routing of securing devices. Add operational constraints or restrictions to the procedures. Make sure the procedures are repeatable in different times and with different operators and ensure that the proper training is provided on the revised procedures.
  - Recommendation 4 (R4)- Make tie procedure more specific, review and update existing drawings and develop new as needed.
  - Recommendation 5 (R5)- Limit use of temporary stow configurations, develop a temporary stow process for each deployable.
    - (R5A)- Set standards for maximum length of time allowed for and operational constraints or restrictions on temporary stows.
  - Recommendation 6 (R6)- Review existing planning and approval processes to ensure critical Certified Principle Engineer(s) CPE(s) are fully engaged; this includes their being identified based on current configuration and proposed operation, and specifically polled with regard to the safety of the proposed operation.
  - Recommendation 7 (R7)- Modify agenda of operational planning meetings to call out discussion on "special" hardware configuration conditions:
    - Non flight hardware connected to the spacecraft
    - Temporarily stowed deployment hardware
    - Missing flight hardware
    - Flight hardware with known operational constraints or restrictions
  - Recommendation 8 (R8)- Take and maintain photos of non standard spacecraft configurations prior to testing and/or spacecraft movements.

Significant Observations:

- Observation 1 (O1)- Lacing cord was used successfully in a similar application in 2003. The technician who performed the stowing operation in 2003 was interviewed. He stated that the lacing cord was placed on the antenna in similar fashion; however it was doubled up at each location. The technician specifically stated using two "ties" at each location, using a mid-sized lacing tape. This would explain why the operation was successful in 2003.
- Observation 10 (O10)- Operational constraints did not specify personnel "keep out" zones for inadvertent deployments, and a QA representative on the floor was in the proximate location of the swinging SRA.
    - Recommendation 9 (R9)- Implement "keep out" zones for temporarily stowed deployables during operations which move the spacecraft.

National Aeronautics and
Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

June 19, 2007

To:	NASA Headquarters Attn: Chief Safety and Mission Assurance Officer
From:	AA/Director
Subject:	Final Approval of the NOAA N' Search and Rescue Inadvertent Deployment Mishap Investigation Team

The MIT for the NOAA N' Search and Rescue Inadvertent Deployment mishap was established according to NASA Procedural Requirements (NPR) 8621.1B, "NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating and Recordkeeping," on April 14, 2007, to gather information; analyze the facts, identify the proximate cause(s), root cause(s), and contributing factor(s) relating to the mishap; and to recommend appropriate actions to prevent a similar mishap from recurring.

The review and endorsement of the MIT Report was conducted by the MIT Appointing Official, and the NASA Office of Safety and Mission Assurance.

The receipt of the endorsement letter was completed on July 29, 2007, 2007, and the comments/recommendations of the endorsers were carefully evaluated. Based upon this evaluation, the SRA Inadvertent Deployment Report is approved.

Should you have comments concerning this matter, please reach Dr. Edward Weiler at 301-286-5121 or by e-mail to Edward.J.Weiler@nasa.gov

National Aeronautics and

Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

June 19, 2007

To:	**NASA Headquarters** **Attn: Chief Safety and Mission Assurance Officer**
From:	**AA/Director**
Subject:	**Endorsement of the Investigation of the NOAA N' Search and Rescue Antenna Inadvertent Deployment Type C Mishap Report**

I have reviewed the Mishap Investigation Report of the NOAA N' Search and Antenna Rescue Inadvertent Deployment and recommend the report for approval. I concur that the report has been prepared as directed by the appointment letter and meets the requirements specified in NPR 8621.1.

Dr. Edward Weiler

1. MISHAP DESCRIPTION

Summary

The NOAA-N Prime Search and Rescue Antenna (SRA) inadvertently deployed during a spacecraft rotation on April 14, 2007 (Figure 1). This rotation was part of a normal operation to configure the spacecraft for additional antenna and the solar array boom deployments. This procedure (red flag written) had been modified to look for a lost metal washer and a thermal blanket button. The flag to the procedure introduced a counter clockwise rotation before the normal clockwise rotation. The antenna was temporally stowed and held in place via lacing cord. The lacing cord broke and allowed the SRA to inadvertently deploy during the clockwise rotation. The SRA broke through a hard stop bracket and damaged an instrument optical sensor radiator panel. The satellite damage appeared to be minimal (Figures 2 and 3) and there were no injuries to personnel.

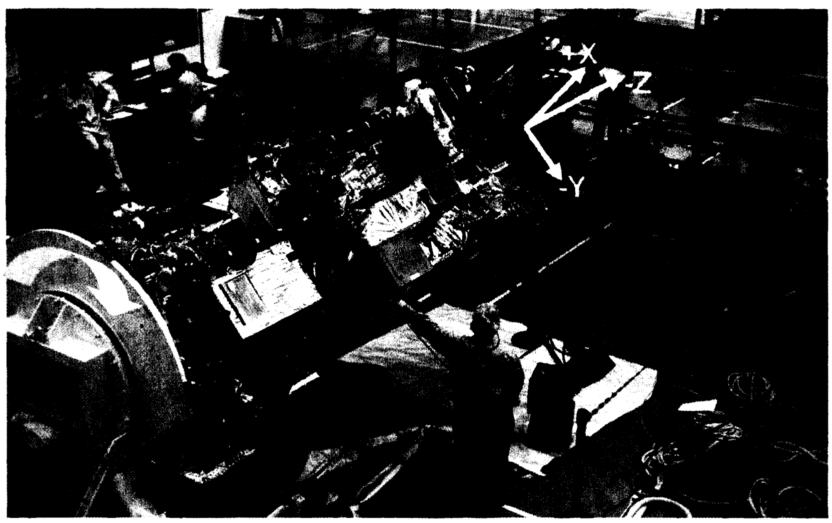

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Figure 1

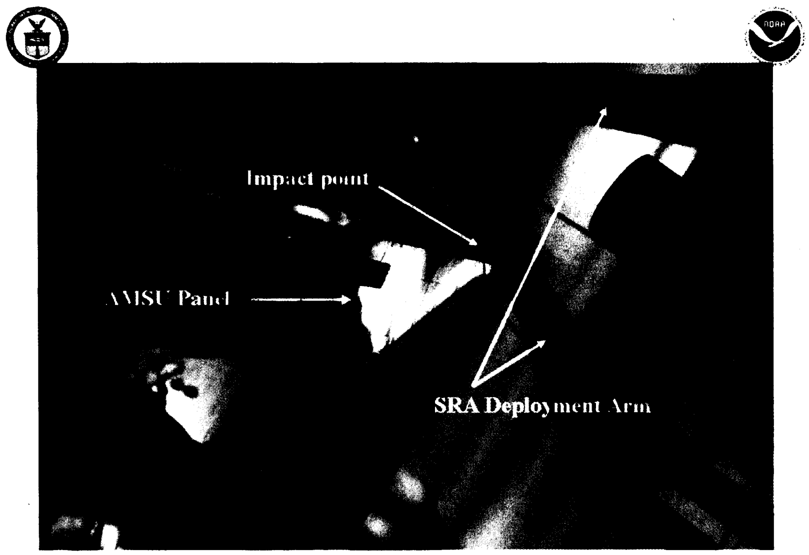

Figure 2

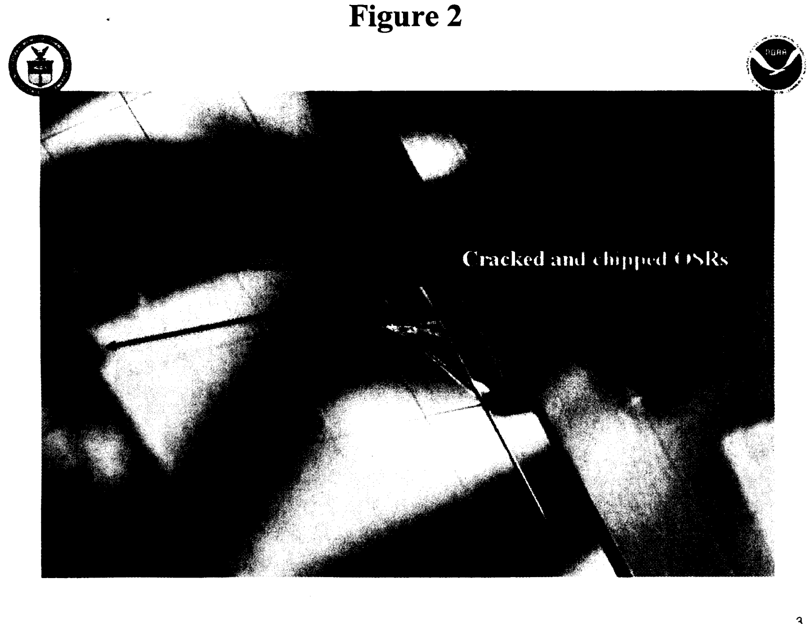

Figure 3

2. Relevant Background:

NOAA-N Prime deployable systems include the SRA, the Solar Array (SA) Panels and Boom, the Very High Frequency (VHF) Real time Antenna (VRA), the Advanced Data collection system Antenna (ADA), and the Ultra High Frequency (UHF) Data collection system Antenna (UDA). The SRA is deployed with the spacecraft in a vertical orientation, with special Mechanical/mobile Aerospace Ground Equipment (MAGE) installed to gravity-negate the antenna. The SA Panels are also deployed with the spacecraft in a vertical orientation, while all other deployments are performed with the spacecraft horizontal. In order to facilitate handling of the spacecraft for these tests, a

Turn Over Cart (TOC) is used which can re-orient the spacecraft from vertical to horizontal, and allow axial rotation of the spacecraft when in the horizontal position. This axial rotation is sometimes referred to as a "rotisserie" motion. An Operational Hazards Assessment (OHA) and Functional Failure Modes and Effects Analysis (FFMEA) were performed for this TOC, but that analysis is primarily focused on the design and load carrying capability of the fixture, without a broad assessment of various possible spacecraft configurations.

The historical Integration and Test (I&T) sequence of events, going back to Television Infrared Operational Satellite (TIROS) N, was for the SRA to be deployed with the spacecraft vertical and removed prior to rotating the spacecraft to a horizontal orientation for other deployments. To accomplish this flow for the SRA, a procedure was run by which the antenna was temporarily "soft" stowed with lacing cord, before being more securely "hard" temporarily stowed with a non-flight bolt and T-nut. The "hard" stow operation required safe placement of multiple personnel so that the antenna could be held in a partially deployed position while pyrotechnic and other hardware was removed. This operation was accomplished with the use of a "Big Joe" lift, which allowed three people to work side by side on the antenna. Subsequent operations to remove the SRA from the spacecraft also required the use of this same lift device. It is important to note that when the procedure was generated, the intended use of the "soft" stow operation was to temporarily safe the SRA until a more secure "hard" stow could be effected, ultimately leading to the SRA being removed before the spacecraft was re-oriented to horizontal.

Sometime in 2002, before similar I&T operations were run for NOAA N-Prime, Lockheed Martin lost the use of the "Big Joe" lift device. SRA stow and removal operations were now limited by the use of the "Marklift" device, which could only accommodate one person on its work platform. This change directly affected practical workflow as it pertained to deployment testing. In December of 2002, following successful deployment of the SRA, the antenna was "soft" stowed using lacing cord. This operation was done in accordance with the existing SRA procedure and prior experience. The "hard" stow operation was "N/A'ed" in the procedure. This is permitted by the project, as the Certified Test Conductor (CTC) is authorized to make modifications to the procedures (procedural note: "per CTC direction, sections of this procedure may be performed out of order as required"). The spacecraft was then rotated to a horizontal position using the turnover cart, a position which allowed the personnel access required to remove the SRA. The SRA, however, was not removed. The plan was to continue with deployment testing of the VRA, and the UDA, which required a rotisserie rotation of the spacecraft while in the horizontal position. Doing the deployments in this sequence offered schedule efficiencies. After all deployment testing was complete, the VRA, UDA and SRA were removed. The lacing cord held, and this new sequence became the new baseline.

This new operational sequence was not originally intended when the lacing cord tie procedure was written, although changes in flow were permitted at the discretion of the CTC. In any case, we now know that the lacing cord tie only worked because the technician performing the operation doubled up the cord. He apparently did this at his own discretion, and the procedure was not specific enough to ensure this would be done in the future.

3. Timeline of Events Leading to the April 14, 2007 Mishap

Pre-vibration test deployments of the SA Boom, VRA, UDA, ADA, SRA and SA Panels were completed on February 12, 2007. Dynamics testing (acoustic, sine vibe, and pyrotechnic shock) was completed on March 13, 2007. With the spacecraft vertical, post-dynamics SA Panel deployment and removal was completed on April 2, 2007. The SRA post-dynamics deployment and temporary stow was completed on April 5, 2007. Lacing cord was used, this time the cord was not doubled up. This technician followed the same vague procedure, and did not happen to tie the lacing cord in the same way the other technician had tied it four years earlier.

Meanwhile, with Dynamics testing nearly finished, and no sign of a missing Microwave Humidity Sounder (MHS) blanket button (first noted missing on January 15, 2007), or of an Advanced Microwave Sounding Unit (AMSU) conductive washer (dropped on February 28, 2007), discussions continued regarding how to disposition the related Q-Notes 200051721 and 200054835. A Material Review Board (MRB) meeting was held on March 12, 2007, and it was decided to continue processing the spacecraft, and look for opportunities for additional inspection after the spacecraft was moved to the TOC, which allowed a -180 to +180 degree rotisserie with the spacecraft in a horizontal orientation. A Flag was later generated (April 5, 2007), authorizing this axial rotation to look for the missing hardware. This Flag was added to the SA Boom deployment procedure, specifying covering the TOC below the spacecraft with scrim prior to rotation to catch/identify any falling debris. This additional operation began with a counterclockwise (CCW) rotation, to be potentially followed by a clockwise (CW) rotation if the missing debris had still not been found.

The spacecraft was moved onto the TOC on April 12, 2007 in preparation for rotating horizontal to facilitate horizontal deployment testing scheduled to begin a few days later. The first test planned was the SA Boom deployment, but it was determined during a Suspended Load Operations (SLO) meeting on April 13, 2007 that additional paperwork was required before that test could be performed. The program decided to continue with other deployments (UDA and ADA) while preparing for the SA Boom deployment. They also decided to move the Flag authorizing axial rotation of the vehicle to look for the missing hardware, from the SA Boom deployment procedure to the ADA deployment procedure (TP-ADA), which was currently being run. While this new deployment sequence did not change the load environment seen by the SRA temporary stow (lacing cord tie restraint) from the baseline test sequence, the Flag did introduce a new CCW rotation that could have affected the SRA cup/cone engagement (if the lacing cord stretched and restraint preload changed) prior to CW rotation. In any case, the lacing cord restraint system, as tied, did not have the load carrying capability required for the CW rotation. The spacecraft was rotated on the TOC from vertical to horizontal at 1620 on 4/13/07, and the work shift ended.

The team met early the following Saturday morning, April 14, 2007, at 0640 for a Pre-Task briefing, which included TP-ADA with the Flag inserted. At 0700 a mini-huddle was held, followed directly by the start of a CCW axial rotation from +X up to +X down, none of the missing material was found and nothing unusual was noted with respect to the SRA temporary restraint. There were several personnel on the floor around the TOC looking and listening for falling debris. After another mini-huddle at 0730, CW axial rotation commenced, to go from +X up back to +X down. After about 50 degrees of rotation from +X up the SRA broke free from its restraint, swung down through its stop point, and hit the AMSU A1 Optical Surface Reflector (OSR) panel before coming to rest in an over deployed position. The area was secured, management notified, witness statements taken, and hardware safed, as the "SRA Inadvertent Deployment" mishap investigation began.

4. Findings and Observations:

Proximate cause:

Proximate Cause (PC)- As tied (with a box knot), the lacing system used to temporarily stow the SRA, could not support the loads it was subjected to during the rotisserie/horizontal operation (Figure 4).

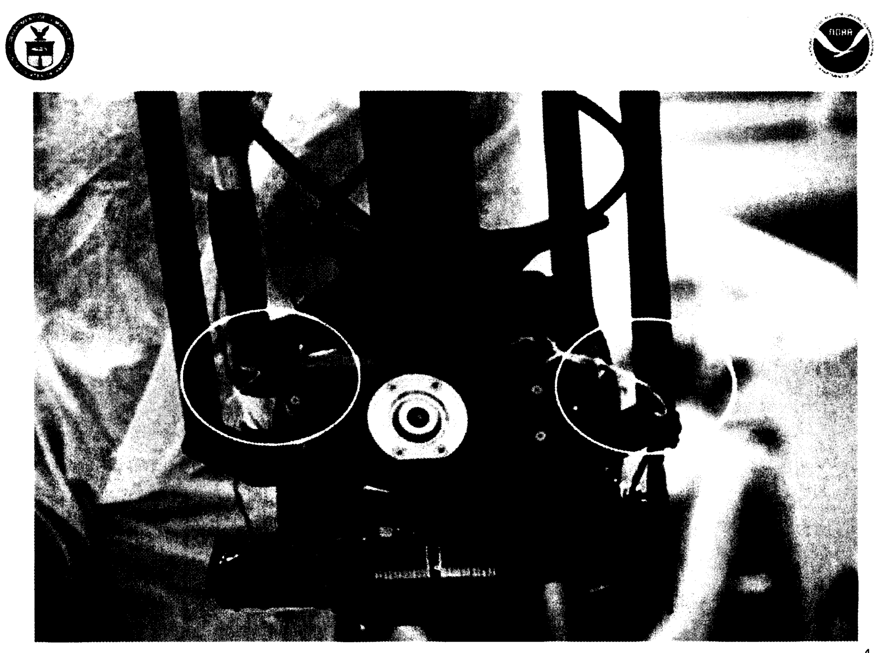

Figure 4

Contributing Factors:

Contributing Factor 1 (CF1)- The tie procedure is non-specific and will not result in a consistent tie performance: no specific requirement of which lacing cord to use (3 sizes were available for use), instructions of how to tie the lacing cord are vague and technician access is limited. Therefore the load capability of as-tied lacing cord restraint is not deterministic.

CF1A- Failure analysis showed the lacing cord used met its manufacturing specifications (Table 1) but that its strength was reduced by ~50% with the introduction of a box knot (Table 2).

CF1B- Structural analysis showed insufficient load-carrying capability of this lacing cord. Load carrying capability of this tie restraint system had never been analyzed prior to the mishap. Subsequent analysis predicts a tension load of up to 69 lbs, which exceeds the specified lacing cord strength of 50 lbs, and the nominal knotted strength of 28 lbs.

Contributing Factor 2 (CF2)- A Functional Failure Modes and Effects Analysis (FFMEA) was not performed for the satellite in this configuration (using a lacing cord tie restraint system for the SRA) and subjected to this operation (horizontal rotisserie).

Contributing Factor 3 (CF3)- Preferred hard stows were difficult to implement since the "Big Joe" lift was removed from usage in 2002.

Contributing Factor 4 (CF4)- The SRA stow procedure did not specify any operational constraints or restrictions.

Observations:

Observation 1 (O1)- Lacing cord was used successfully in a similar application in 2003. The technician who performed the stowing operation in 2003 was interviewed. He stated that the lacing cord was placed on the antenna in similar fashion; however it was doubled up at each location. The technician specifically stated using two "ties" at each location, using a mid-sized lacing tape. This would explain why the operation was successful in 2003.

Observation 2 (O2)- LMMS Fishbone analysis conducted on April 19, 2007supports the causes identified.

Observation 3 (O3)- Applicable procedures and processes were followed.

Observation 4 (O4)- Personnel involved in the operations had proper training and up-to-date certification in accordance with LMMS processes.

Observation 5 (O5)- Operations personnel correctly followed the post mishap procedure.

Observation 6 (O6)- Staff performing this activity had not been overworked. This was the 1st Saturday work in previous six weeks.

Observation 7 (O7)- Appears that previous Mishap Investigation Board (MIB) recommendations from the 2002 incident were followed including the recommendation to review all Integration and Test (I&T) procedures before their use.

Observation (O8)- Responsible SRA systems engineer was not specifically sought out in the planning process for this operation: no process to identify which Certified Product Engineer(s) (CPEs) are critical to engage prior to approving and running an operation based on details of that operation and the spacecraft configuration, no requirement for critical CPE(s) to provide information supporting the safety of an operation.

Observation 9 (O9)- Close out photos of pre-mishap configuration were not taken.

Observation 10 (O10)- Operational constraints did not specify personnel "keep out" zones for inadvertent deployments, and a QA representative on the floor was in the proximate location of the swinging SRA.
Observation 11 (O11)- The SRA procedure spelled out how to install, deploy, temporarily "soft" stow, temporarily "hard" stow, and remove the antenna. The original intent of the temporary "soft" stow (with lacing cord) step in the procedure was only to hold the SRA, with the spacecraft in a vertical orientation, in preparation for a temporary "hard" stow (with bolt).

Root cause:

Root Cause (RC)- Lack of due diligence, inadequate Engineering/Management practices which led to a vague procedure.

5. Recommendations:

Recommendation 1 (R1)- Evaluate all spacecraft configurations to ensure adequate margin exists for the stowage of all deployables.

R1a- Minimize the use and time allowed for temporary stowage of deployables.

R1b- Reexamine all spacecraft configurations for the safety of flight hardware and personnel.

Recommendation 2 (R2)- If used, the load carrying capability of this tie approach should be conservatively assessed.

2A (R2A)- Perform FFMEAs and ensure conservative load carrying capability for this or any temporary stow approach includes appropriate factors of safety for a proposed operation.

Recommendation 3 (R3)- Review all heritage spacecraft procedures that address deployable stowage to ensure they are specific on the type and size, number, location and routing of securing devices. Add operational constraints or restrictions to the procedures. Make sure the procedures are repeatable in different times and with different operators and ensure that the proper training is provided on the revised procedures.
Recommendation 4 (R4)- Make tie procedure more specific, review and update existing drawings and develop new as needed.
Recommendation 5 (R5)- Limit use of temporary stow configurations, develop a temporary stow process for each deployable.

(R5A)- Set standards for maximum length of time allowed for and operational constraints or restrictions on temporary stows.

Recommendation 6 (R6)- Review existing planning and approval processes to ensure critical Certified Principle Engineers CPE(s) are fully engaged; this includes their being identified based on current configuration and proposed operation, and specifically polled with regard to the safety of the proposed operation.
Recommendation 7 (R7)- Modify agenda of operational planning meetings to call out discussion on "special" hardware configuration conditions:

- Non flight hardware connected to the spacecraft
- Temporarily stowed deployment hardware
- Missing flight hardware

- Flight hardware with known operational constraints or restrictions

Recommendation 8 (R8)- Take and maintain photos of non standard spacecraft configurations prior to testing and/or spacecraft movements.
Recommendation 9 (R9)- Implement "keep out" zones for temporarily stowed deployables during operations which move the spacecraft.

6. NOAA-N Prime Incident 2003

The MIT reviewed the NOAA-N Prime incident that occurred in 2003 to see if the possible causes of this incident were somehow connected. We reviewed the proximate cause and root causes for applicability. We also evaluated the implementation of the pertinent 2003 incident recommendations. In the end, we didn't find any systemic connection between the causes of this incident and the 2003 incident. In addition, we felt that the previous recommendations that were applicable were implemented.

The original incident occurred on Saturday, September 6, 2003 during an operation at Lockheed Martin Space Systems Company (LMSSC) Sunnyvale California that required repositioning the Television Infrared Observational Satellites (TIROS) National Oceanic and Atmospheric Administration (NOAA) N-Prime satellite from a vertical to a horizontal position, the satellite slipped from the Turn-Over Cart (TOC) and fell to the floor. The satellite sustained heavy damage although no injuries to personnel occurred.

The operation scheduled for that day was to shim the Microwave Humidity Sounder (MHS) instrument by removing and replacing the instrument. This operation required the spacecraft to be rotated and tilted to the horizontal position using the TOC. The spacecraft fell to the floor as it reached 13 degrees of tilt while being rotated.

Proximate cause (PC1): The NOAA N-Prime satellite fell because the LMSSC operations team failed to follow procedures properly configure the TOC, such that the 24 bolts that were needed to secure the TOC adapter plate to the TOC were not installed.

The root causes identified by the MIB were summarized as: R1) The TOC adapter was not secured to the TOC because the LMSSC operations team failed to execute their satellite handling procedures. R2) The LMSSC operations team's lack of discipline in following procedures evolved from complacent attitudes toward routine spacecraft handling, poor communication and coordination among operations team, and poorly written or modified procedures. R3) The preconditions within integration and test (I&T) operations described above existed because of unsafe supervision practices within the LMSSC project organization, including ad hoc planning of operations, inadequate oversight, failure to correct known problems, and supervisory violations. R4) The unsafe supervision practices within the TIROS program had their roots in the LMSSC organization: the inadequate resources and emphasis provided for safety and quality assurance functions: the unhealthy mix of dynamic I&T climate with a well-established program and routine operations; and the lack of standard, effective process guidelines and safeguards for operations all negatively influenced the project team and activities. R5) The in-plant government representation, Defense Contract Management Agency

(DCMA), and the Goddard Space Flight Center (GSFC) Quality Assurance (QA)/safety function failed to provide adequate oversight to identify and correct deficiencies in LMSSC operational processes, and thus failed to address or prevent the conditions that allowed the mishap to occur. R6) The Governments inability to identify and correct deficiencies in the TIROS operations and LMSSC oversight processes were due to inadequate resource management, an unhealthy organizational climate, and the lack of effective oversight processes.

MIB Implementation Review Team

One of the recommendations coming out of the September 3, 2004 NOAA-N Prime Investigation Report was a separate follow-up investigation should be conducted to further examine and characterize a number of systemic problems.

In response, on August 30, 2005 the first Implementation Review Team (IRT) independent review was successfully held. The review team consisted of non-POES project experts from NASA and NOAA. The POES project was very responsive and open in providing the data the review team needed to address compliance with the 8 MIB recommendations. It was this teams view that all of the MIB recommendations were being adequately (fully) implemented.

In November of 2006 the NASA/NOAA NOAA N' Implementation Review Team met for the second time and their assessment is as follows:

The second Implementation Review Team (IRT) independent review was successfully held on November 2, 2006. The review team consisted of non-POES project experts from NASA and NOAA. The POES project was very responsive and open in providing the data the review team needed to address continued compliance with the 8 Mishap Investigation Board (MIB) recommendations. It is this team's assessment that all of the MIB recommendations were still being fully implemented. In addition, the POES project implemented all of the recommendations made by the IRT in August, 2005.

Tensile Test Results

- Straight tensile pull tests from TIROS provided spools
- Sizes tested -0050 and -0015
- -0050 used to secure SRA
- LAC 25-5003-0050
  - Max Elong: 40% -- Pass
  - Min. Load: 50 lbs -- Pass
- LAC 25-5004-0015
  - Max Elong: 40% -- Pass
  - Min. Load: 15 lbs – Pass

Specimen label Lot No. (Lot –Tension – Trial)	Elongation (%)	Max Load lbf	Dash No.
100603-T-1	20	62.9	-0050
100603-T-3	20	63.3	
100603-T-4	20	63.2	
100603-T-5	13	61.7	
100603-T-6	23	63.6	
100603-T-7	20	63.0	
Average	**19**	**62.9**	
Std. Dev	3	0.6	
052206-T-1	20	66.3	-0050
052206-T-2	23	63.0	
052206-T-3	20	64.9	
052206-T-4	23	66.8	
052206-T-5	20	67.2	
Average	**21**	**65.6**	
Std. Dev	2	1.7	
3181-T-1	17	29.8	-0015
3181-T-2	17	27.7	
3181-T-3	17	29.3	
3181-T-4	13	30.1	
3181-T-5	17	29.0	
3181-T-6	13	29.9	
Average	**16**	**29.3**	
Std. Dev	2	0.9	

Table 1

Tensile Test Results – Knots

- Tensile tests with knots
- Knots tied by TIROS Tech
- Breaks observed at knots
- Substantial reduction in breaking strength with knots
  - (62.9-28.2)/62.9 = 54%
  - (65.6-27.9)/65.6 = 57%

Specimen label Lot No. (Lot – (Knot) – Trial)	Max. Load (lbf)	Dash No.
052206-Square Knot-1	28.3	-0050
052206-Square Knot-2	29.5	
052206-Square Knot-3	23.7	
052206-Square Knot-4	26.7	
052206-Square Knot-5	32.7	
Average	**28.2**	
Std. Dev.	3.3	
100603-Square Knot-1	28.4	-0050
100603-Square Knot-2	25.6	
100603-Square Knot-3	27.2	
100603-Square Knot-4	25.9	
100603-Square Knot-5	32.2	
Average	**27.9**	
Std. Dev.	2.7	
3181-Square Knot-1	12.1	-0015
3181-Square Knot-2	13.3	
3181-Square Knot-3	9.6	
3181-Square Knot-4	12.5	
3181-Square Knot-5	14.1	
Average	**12.3**	
Std. Dev.	1.7	

Table 2

ACRONYMS LIST

ADA	Advanced Data collection system Antenna
AMSU	Advanced Microwave Sounding Unit
CPE	Certified Product Engineer
CTC	Certified Test Conductor
CW	Clockwise
CF	Contributing Factor
CCW	Counterclockwise
DCMA	Defense Contract Management Agency
FFMEA	Functional Failure Modes and Effects Analysis
GSFC	Goddard Space Flight Center
IRT	Implementation Review Team
I&T	Integration and Test
LMMS	Lockheed Martin Missiles and Space
LMSSC	Lockheed Martin Space Systems Company
MRB	Material Review Board
MAGE	Mechanical/mobile Aerospace Ground Equipment
MHS	Microwave Humidity Sounder
MIT	Mishap Investigation Team
NOAA	National Oceanic and Atmospheric Administration
OHA	Operational Hazards Assessment
OSR	Optical Sun Reflector
PC	Proximate Cause
QA	Quality Assurance
RC	Root Cause
SRA	Search and Rescue Antenna
SA	Solar Array
SLO	Suspended Load Operations
TIROS	Television Infrared Operational Satellite
TOC	Turn Over Cart
UDA	UHF Data collection system Antenna
UHF	Ultra High Frequency
VHF	Very High Frequency
VRA	VHF Real Time Antenna

1.2 Signature Pages

Concurrences by Board members:

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Phillip Sabelhaus
Chairperson
Code 443/Goddard Space Flight Center

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Mike Hagopian
Voting Member Volunteer

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Eric Clemons
Voting Member
NOAA

Concurrence by Ex-Officio Board Member:

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Jerome Kosko
Safety
Code 300/GSFC